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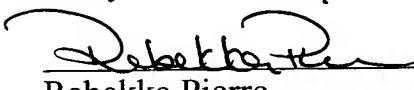
Docket No.: S4-03P09159

C E R T I F I C A T I O N

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Hollywood, Florida



Rebekka Pierre

February 1, 2006

Lerner Greenberg Stemer LLP
P.O. Box 2480
Hollywood, FL 33022-2480
Tel.: (954) 925-1100
Fax.: (954) 925-1101

1 Description

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2
3 Electronic unit and method for manufacturing an electronic unit
45 The present invention relates to an electronic unit, in
6 particular a control device for a motor vehicle, comprising at
7 least one printed circuit board which is populated with
8 electronic components and a housing that encloses the printed
9 circuit board. Furthermore, the invention relates to a method
10 for manufacturing such an electronic unit and to a use of such
11 an electronic unit.12
13 In the field of motor vehicle electronics, control devices for
14 controlling electrical and electronic vehicle components (e.g.
15 engine control devices) are well known, the circuit board
16 (circuit carrier) being manufactured by means of thick-film
17 technology or laminate technology in order to achieve greater
18 temperature stability.19
20 In the case of thick-film technology, provision is made for a
21 relatively thick ceramic substrate with likewise relatively
22 thick fired-on conductor paths, for example. This has clear
23 cost disadvantages, since the manufacturing of such a printed
24 circuit board is significantly more expensive than the
25 manufacturing of a simple printed circuit board (e.g.
26 comprising a thin epoxy substrate).27
28 In the case of laminate technology, a conventional printed
29 circuit board is combined with a metal layer to form a laminate
30 by applying a high pressure and a high temperature, for
31 example. This is disadvantageous in that the printed circuit
32 board which is manufactured using laminate technology can only
33 be populated with electronic components on one side, and
34 therefore the surface requirement in a predetermined electronic
35 circuit arrangement is greater in comparison with conventional

1 printed circuit boards which are populated on both sides.
2 Avoiding the increased surface requirement by arranging two or
3 more printed circuit boards one above the other, for example,
4 is often unsatisfactory since the construction space and the
5 assembly costs are increased in this case.

6

7 In general, it is important in many application scenarios to
8 implement an efficient heat dissipation from the electronic
9 components to the housing, in particular if e.g. active
10 semiconductor power components are used in the electronic unit
11 and/or the electronic unit will be used in an environment
12 featuring comparatively high ambient temperature. This applies
13 in the case of control devices for vehicles, for example, which
14 control devices are arranged in the vicinity of or directly at
15 an internal combustion engine, e.g. in order to simplify the
16 wire harness configuration of the vehicle or in order to allow
17 the engine to be electronically tested together with the
18 associated control device in a simple manner. The above cited
19 thick-film technology or laminate technology are usually used
20 for the known control devices which are installed close to the
21 engine.

22

23 The invention addresses the problem of improving an electronic
24 unit of the type cited at the beginning in respect of heat
25 dissipation properties and in respect of manufacturing costs.

26

27 This problem is solved by an electronic unit as claimed in
28 claim 1 and a method for manufacturing an electronic unit as
29 claimed in claim 11. The dependent claims relate to
30 advantageous developments of the invention.

31

32 The electronic unit according to the invention includes at
33 least one printed circuit board section which is arranged at a
34 distance from the housing and is populated on both sides with
35 electronic components. This or these printed circuit board

1 sections are subsequently designated as "first printed circuit
2 board section(s)". The printed circuit board also includes at
3 least one printed circuit board section which is connected to
4 the housing via a heat-conducting adhesive layer. This or these
5 printed circuit board sections are subsequently designated as
6 "second printed circuit board section(s)". In the case of a
7 multipart housing, this bonding to the second printed circuit
8 board section or sections can occur at any of the housing
9 parts. As a result of the partially two-sided component
10 mounting (on the first printed circuit board section, of which
11 there is at least one), there is a comparatively smaller
12 surface requirement, particularly if the portion of the first
13 printed circuit board section or sections represents at least
14 30% of the total printed circuit board surface. Furthermore,
15 the second printed circuit board section advantageously acts as
16 both a mechanical and thermal "interface" to the housing, which
17 should be considered in this regard as both a mechanical base
18 and a heat sink. According to the invention, the connection via
19 an adhesive layer makes the design of this dual-purpose
20 interface very efficient, favorable in terms of manufacturing,
21 and economical in terms of space.

22

23 For the sake of simplicity, reference is only made to the first
24 printed circuit board section or second printed circuit board
25 section in the following, even though a plurality of such
26 sections can be provided in each case. The explanations which
27 are provided for such a printed circuit board section can then
28 readily be applied to more than one or all of the relevant
29 plurality of printed circuit board sections.

30

31 That side of the second printed circuit board section to which
32 the adhesive layer is applied is preferably provided with a
33 metal surface (extended conductor path), in order to achieve
34 horizontal heat spreading and good thermal connection to the
35 adjoining adhesive layer. That side of a second printed circuit

1 board section which is opposite to the adhesive layer is highly
2 suitable for fitting with electronic components which produce
3 particularly large amounts of heat, since this heat can be
4 transferred via the nearby underlying adhesive layer which has
5 little heat transmission resistance, in particular via heat-
6 conducting metallized through openings ("vias") which are
7 arranged at this position.

8
9 The adhesive is preferably applied as liquid adhesive and then
10 cured. The curing of the adhesive can easily be performed
11 thermally. For good heat dissipation efficiency, the use of an
12 adhesive having a thermal conductivity of at least 0.5 W/mK, in
13 particular at least 1 W/mK, is preferred.

14
15 The adhesive layer connection between the printed circuit board
16 and the housing makes it possible to dispense with the screw
17 connection which is usually provided in conventional electronic
18 units for the purpose of fastening. If the electronic unit has
19 a plurality of printed circuit boards which are stacked in
20 parallel with each other, the further printed circuit boards
21 can likewise be fastened inside the housing by means of bonding
22 and/or conventional screw connection, e.g. using suitable
23 spacers.

24
25 In an embodiment, the housing comprises a housing floor and a
26 housing cover which is connected thereto. This has the
27 advantage that the manufacturing of the electronic unit can be
28 done in a simple manner by initially gluing the already
29 populated printed circuit board into place in one of these
30 housing parts and then closing the housing by connecting
31 between housing floor and housing cover. For good heat
32 dissipation through the housing, it is advantageous if the
33 entire housing or at least that part of the housing which is
34 thermally connected to the printed circuit board via the
35 adhesive layer is made of a material offering good thermal

1 conductivity such as, for example, metal (e.g. aluminum alloy).

2
3 In a preferred embodiment, the housing floor includes cross-
4 sectional indentations for providing housing internal sections
5 that are used for connecting to the second printed circuit
6 board section via the adhesive layer, there being at least one
7 such second printed circuit board section.

8
9 A connection between housing floor and housing cover, which
10 connection is simple in terms of manufacturing, can be
11 implemented by means of a glued groove-and-projection
12 connection. In particular, the adhesive which is in any case
13 required for the connection between printed circuit board and
14 housing can be used for this purpose. The housing internal
15 space can be effectively protected against contamination by
16 means of a structure in which an annularly continuous
17 projection running around the edge of a housing part (floor or
18 cover) engages in a correspondingly arranged groove in the
19 other housing part.

20
21 In particular, for a low construction height of the electronic
22 unit, it is beneficial to integrate at least one electrical
23 plug connector in the housing cover in order to provide an
24 electrical connection possibility. According to the invention,
25 terminal pins of the plug connector can run straight to the
26 printed circuit board which is adjacent to the housing cover,
27 and can be contacted directly onto this printed circuit board.

28 In particular, in the case of this straight terminal pin
29 alignment, the contacting can be provided easily in the form of
30 press-in contacting, e.g. by placement of the housing cover
31 which is equipped with the plug connector or connectors onto
32 the housing floor when the housing is closed.

33
34 The specific arrangement of the second printed circuit board
35 section or sections (considered in the plane of the printed

1 circuit board) has a bearing on the fastening and the heat
2 dissipation properties. In this context, it has proven
3 beneficial if at least two second printed circuit board
4 sections are provided, whose minimal reciprocal distance is
5 greater than 40% of a maximal printed circuit board extent.
6 This is primarily advantageous for stable storage of the
7 printed circuit board which is mounted at the second printed
8 circuit board sections. Irrespective of this, it is beneficial
9 if at least one of the second printed circuit board sections is
10 arranged at a printed circuit board edge. Finally, it is also
11 beneficial in this respect if at least one of the second
12 printed circuit board sections runs along a large part of a
13 printed circuit board edge, and particularly in an annularly
14 continuous manner along a printed circuit board edge. Such an
15 annular connection of the printed circuit board to the housing
16 holds the printed circuit board in a particularly stable manner
17 and results in a particularly uniform heat dissipation during
18 operation of the electronic unit.

19
20 Where the printed circuit board side which is opposite to the
21 adhesive layer is not populated with electronic components in a
22 first printed circuit board section, this location is suitable
23 for arranging a conductor path surface which acts as a heat
24 spreading surface and can efficiently dissipate the accumulated
25 heat to the underlying adhesive layer.

26
27 A simple method for manufacturing the electronic unit can
28 include, for example, the following steps:

- 29
30 - providing the already populated printed circuit board,
31
32 - providing a contoured housing floor having raised housing
33 internal areas and having a groove which runs around the
34 edge of the housing floor,

- 1 - depositing liquid adhesive to the raised housing floor
- 2 areas and to the base of the groove,
- 3
- 4 - pressing on the printed circuit board in order to bond
- 5 said printed circuit board onto the raised housing floor
- 6 surfaces,
- 7
- 8 - providing a housing cover having a projection which is
- 9 suitable for engaging in the housing floor groove, and
- 10
- 11 - pressing the housing cover onto the housing floor in order
- 12 to create a glued groove-and-projection connection between
- 13 housing floor and housing cover and in order to contact
- 14 terminal pins of the plug connector arrangement via press-
- 15 in technology.

16
17 The plug connector arrangement can be contacted to the printed
18 circuit board, e.g. after the printed circuit board has been
19 populated, by means of press-in technology before the printed
20 circuit board is bonded. Alternatively, for example, it is
21 possible for the plug-connector arrangement to be integrated in
22 the housing cover and pressed on together with the housing
23 cover.

24
25 The invention is described in greater detail below with
26 reference to an exemplary embodiment and with reference to the
27 attached drawings, in which:

- 28
29 Fig. 1 shows an exploded view of a control device for a
30 vehicle,
31
32 Fig. 2 shows a sectional view of the control device in the
33 assembled state in longitudinal section, and
34
35 Fig. 3 shows a sectional view of the control device in the

1 assembled state in cross section.

2
3 The Figures 1 to 3 show a control device for a vehicle, said
4 control device having the overall designation of 10. The
5 control device 10 is formed from a rigid printed circuit board
6 12 (e.g. epoxy substrate with copper conductor paths or
7 surfaces), said printed circuit board being populated with
8 electronic components, and a housing which encloses this
9 printed circuit board, said housing being designed in two parts
10 and comprising a housing floor 14 (base plate) and a housing
11 cover 16. For the electrical connection of the control device
12 to the vehicle electronics of the relevant motor vehicle (e.g.
13 to a test device), provision is made for two plug connectors
14 18, 20 which, for the purpose of contacting, are placed on the
15 upper side of the printed circuit board 12 in the illustrated
16 exemplary embodiment by means of press-in technology during the
17 assembly of the control device and are screwed to the housing
18 floor 14. For this purpose, the plug-connector housings are
19 provided with fastening screws 22 which, in the assembled
20 state, pass through openings 24 in the printed circuit board 12
21 and are screwed into corresponding fastening holes 26 in the
22 housing floor 14. The plug connectors 18, 20 pass through
23 suitably dimensioned through openings 28 of the housing cover
24 16 towards the exterior.

25
26 The housing floor 14, which like the housing cover 16 is made
27 of an aluminum alloy, has a shape that is contoured in such a
28 way that a coherent, approximately rectangular, deepened
29 housing internal section 30 is produced in the central area of
30 the floor 14, said section being contiguous around its edge
31 with a raised housing internal section 32.

32
33 Corresponding to this arrangement of deepened and raised
34 housing internal sections 30, 32, the printed circuit board 12
35 has a coherent central printed circuit board section 34 (first

1 printed circuit board section) which in the assembled state is
2 arranged at a certain distance from the housing floor and which
3 is populated on both sides with electronic components, whereas
4 the printed circuit board 12 has an outer printed circuit board
5 section 36 (second printed circuit board section) which runs in
6 an annularly continuous manner along the printed circuit board
7 edge and whose underside is directly connected to the raised
8 housing internal section 32 via a heat-conducting adhesive
9 layer 42 (Fig. 2 and 3).

10

11 This partial connection of the printed circuit board 12 via the
12 adhesive layer 42 guarantees a reliable mechanical retention of
13 the printed circuit board 12 and moreover acts as an efficient
14 dissipation path for heat which is produced by the electrical
15 components during the operation of the control device 10. The
16 adhesive has a thermal conductivity of approximately 2 W/mK.
17 Consequently, the control device 10 is suitable in particular
18 for installation close to the engine in a motor vehicle, since
19 the described structure can cope well with the harsh
20 environmental conditions in terms of mechanical stresses (e.g.
21 vibrations) and temperature.

22

23 The illustrated engine control device 10 involves the use of a
24 number of active power semiconductor components, e.g. in a
25 circuit area for DC/DC step-down conversion of an on-vehicle
26 voltage for supplying a circuit part for digital signal
27 processing, or in a circuit area for DC/DC step-up conversion
28 for supplying a circuit part for controlling a fuel injector
29 arrangement of the internal combustion engine. These electronic
30 power components are generally arranged on the upper side of
31 the outer printed circuit board section 36, since an efficient
32 heat dissipation away from this section downwards through the
33 adhesive layer 42 to the housing is possible.

34

35 The plug connectors 18, 20 which are used in the illustrated

1 exemplary embodiment have terminal pins which run straight
2 downwards and can be pressed into correspondingly dimensioned
3 contact holes in the printed circuit board 12 ("press-fit"
4 technology), thereby offering ease of manufacturing. The use of
5 such non-bent terminal pins has a further advantage in that the
6 plug connectors 18, 20 can be integrated in the housing cover
7 16 (either before or after the housing is closed), this being
8 beneficial with regard to the base surface of the control
9 device 10, and not integrated in a housing side wall area as
10 often occurs in the case of conventional control devices and
11 thereby unnecessarily increases the base surface of the
12 housing. Finally, the contacting of the terminal pins in the
13 central printed circuit board section 34 has the advantage that
14 the conductor paths of the printed circuit board 12 which lead
15 from electronic components to the terminal pins can be arranged
16 comparatively simply in the sense of a less complicated circuit
17 board layout. In particular, the course of the conductor paths
18 between individual components and individual terminal pins
19 tends to be shorter and more direct. By contrast, the printed
20 circuit board layout is more costly and less compact in terms
21 of the required printed circuit board surface when contacting
22 is provided at the edge area of the printed circuit board, as
23 is often the case in conventional control devices with angled
24 plug-connector terminal pins. With regard to the heat
25 dissipation properties of the described control device 10, the
26 centrally-oriented arrangement of the plug connectors 18, 20 is
27 moreover also advantageous in that the terminal pins, which
28 dissipate rather than generate heat, are arranged in that
29 printed circuit board section (34) which is less efficiently
30 cooled than the outer printed circuit board section 36, and in
31 that the terminal pins do not require any printed circuit board
32 surface in the efficiently cooled outer printed circuit board
33 section 36, this being preferably used for fitting with
34 components that generate significant heat (e.g. power
35 transistors).

1 When assembling the control device 10, a liquid adhesive (e.g.
2 silicone-based) is applied to the raised housing internal
3 section 32 and to the base of a groove 38 which runs around the
4 housing floor 14. The already populated printed circuit board
5 12 is then positioned in the housing floor 14 and placed on the
6 adhesive layer. The plug connectors 18, 20 and their terminal
7 pins are then contacted to the printed circuit board 12 using
8 press-in technology and fastened by means of the fastening
9 screws 22. In the illustrated exemplary embodiment, the
10 screwing of the plug connectors 18, 20 acts as an additional
11 (not necessary per se) fastening of the printed circuit board
12 12 in the housing floor 14. Finally, the housing cover 16 is
13 emplaced from above in such a way that an extending projection
14 40 which runs around the edge of said cover engages in the
15 groove 38 and is bonded thereto. Alternatively, the plug
16 connectors 18, 20 can be attached to the upper side of the
17 printed circuit board first. If a groove is provided around the
18 plug connectors, the connection between the plug connectors 18,
19 20 and the housing cover 16 can also be implemented
20 advantageously by means of a groove-and-projection bond.

22

23

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